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EROSION LOSSES

from a 3-day

CALIFORNIA STORM

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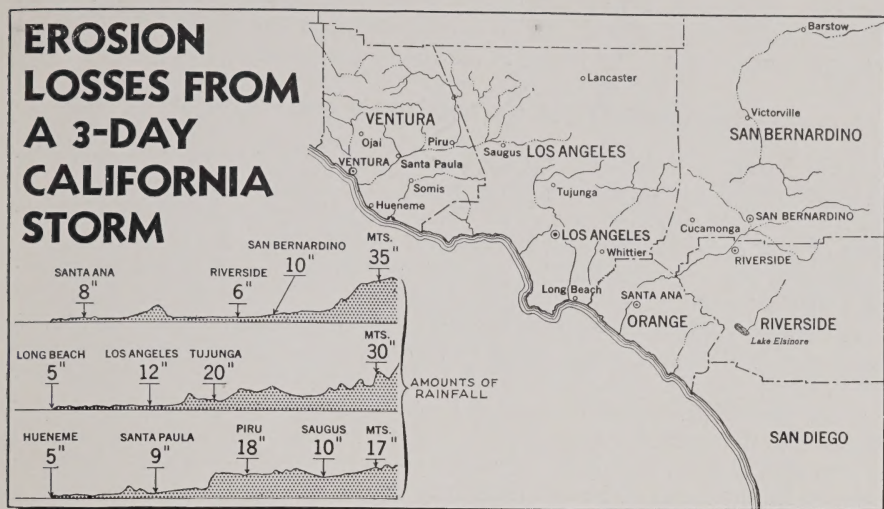
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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE



This field held the water from an 8-inch rain.



By John G. Bamesberger, regional engineer, Soil Conservation Service

AREAS INCLUDED IN THE REPORT

ON THE AFTERNOON of February 28, 1938, a great storm swept in from the Pacific Ocean, drenching six counties in southern California. Before the skies cleared on the afternoon of March 3, \$100,000,000 worth of damage had been done, 70 lives had been lost, and havoc had been wrought to thousands of acres of rich and productive agricultural land.

In the counties most severely affected by the storm are the Las Posas, the La Habra, and the Aliso Creek demonstration projects and two C. C. C. work areas under the direction of the Soil Conservation Service. On these project and work areas the Service recorded the rainfall and measured its erosive effects as it flowed from the land. The storm was not of high intensity. The greatest rainfall intensity for any 10-minute period was the not unusual rate of 0.9 inch per hour. But since the storm extended over 3 days and the precipitation for the five areas averaged 8 inches, erosion-control practices were subjected to an unusually severe test. This report tells how measures of soil defense adopted by farmers in these areas withstood the stress imposed on them.

These five areas, comprising more than 140,000 acres, represent a wide variety of soils and slopes and wide differences in the condition of the land at the time of the storm. Characteristic of the 40,000-acre Las Posas project area in Ventura County are the steep and sparsely covered hills and long, narrow valleys, with deep barrancas coursing down their entire length (p. 6).

The La Habra area, comprising approximately 25,000 acres in Los Angeles and Orange Counties, is largely in orchards, pasture, and hay fields. Slopes range up to as much as 50 percent. On the steeper

slopes are terraced orchards, protected by cover crops. In contrast to this well-protected area is the 25,000-acre Aliso Creek project, in Orange County, where cultivated slopes range up to 25 percent and a large percentage of the land is in beans and grain.

INTERPRETATION OF THE DATA ON EROSION

This report is not based on exhaustive or rigidly conducted investigations, but every effort has been made to keep the study within such limits of accuracy that the data recorded will give a reliable description of soil erosion and erosion-control practices after the storm.

Since a few farmers on the project and work areas failed to maintain erosion-control structures and to follow recommended practices and since on some areas two or more erosion-control practices were used in combination, the data in the tables and charts may vary somewhat from the observations usually reported in studies of soil conservation practices. The limitations imposed by the conditions under which the measurements were made are of course not apparent in the tables and charts, and it is therefore recommended that these be considered in the light of the explanatory text.

METHOD OF MEASURING SOIL LOSS

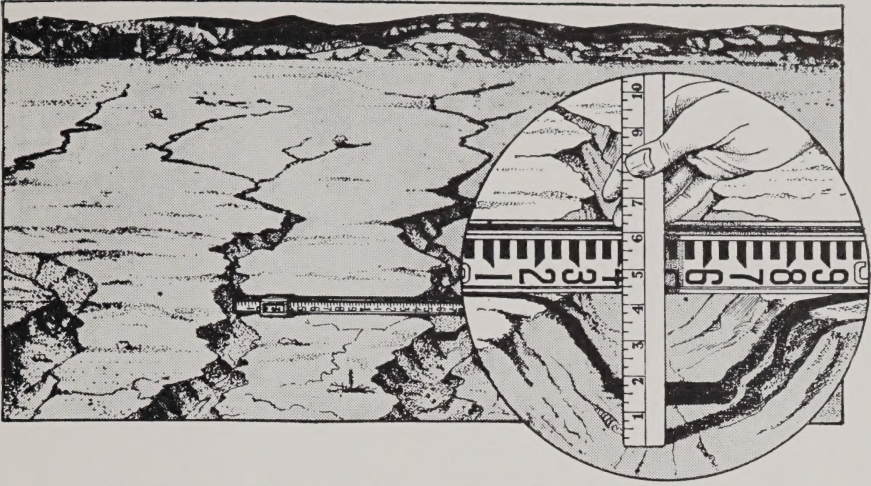
The soil losses in the five demonstration areas were determined by sampling. A number of representative cross sections were selected in each field. The loss of soil was determined by placing a straight-edge on the ground level and measuring the eroded profile, as shown in the first illustration on the opposite page. The average soil loss was computed for each sample, and the average of all samples from a field was taken to be the average loss of that field.

EROSION GROUPS

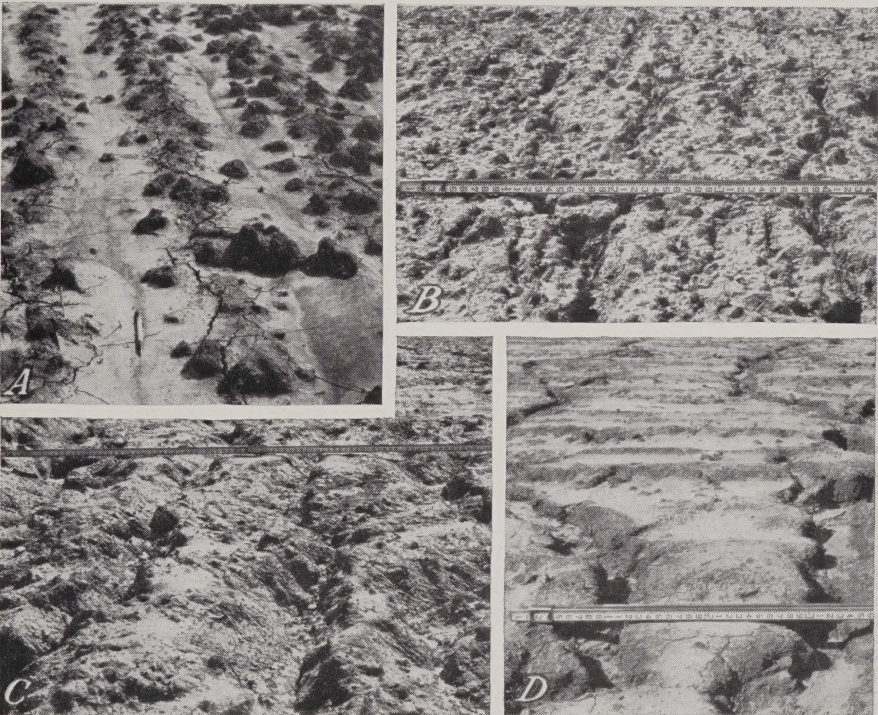
Since the amount of erosion caused by the storm varied greatly, erosion groups were used to designate the various degrees of damage. Group 1 had no erosion. Group 2 lost less than $\frac{1}{4}$ inch of soil and had an average loss of $\frac{1}{8}$ inch. Group 3 lost from $\frac{1}{4}$ to $\frac{1}{2}$ inch, with an average loss of $\frac{3}{8}$ inch. Group 4 lost from $\frac{1}{2}$ to 1 inch, with an average loss of $\frac{3}{4}$ inch. Group 5 lost from 1 to 2 inches, with an average loss of $1\frac{1}{2}$ inches. All losses of 2 inches and over were included in group 6, for which a 3-inch loss was considered average. The average depth of erosion of a group was used in determining total soil loss. Eroded areas in groups 2, 4, 5, and 6 are shown on the opposite page.

WHAT THE REPORT CONTAINS

At the time the extent of erosion was measured, the type of treatment of the land, the kind and condition of cover, slope, soil type, condition of soil, and previous condition of erosion were recorded. From these records was obtained the information reported here. Measurements were also made of the size of new gullies, erosion in the old gullies, the area covered by deposits, the depth of the overwash, and the extent of landslips. The number of new gullies and landslips



This diagram shows how measurements of soil loss were made.



Four of the six erosion groups: *A* and *C*, respectively, represent the groups that have the least and greatest soil loss; *B* represents group 4, which has an average loss of $\frac{3}{4}$ of an inch; and *D* represents land that lost an average of $1\frac{1}{2}$ inches.



In the La Habra demonstration area (above) the steep slopes are largely protected by an excellent plant cover, and they lost little soil. The contour-planted orchard in the foreground is an avocado grove. In the background are pasture and grain lands.

The high erosional losses in the Las Posas project (below) originated largely on areas supporting a rather poor plant cover. All the native cover on the hills in the background was destroyed by fire the fall before this picture was taken.



was recorded. The first part of the report covers the relation of soil loss to type of treatment of the land, crops, cover, soils, and slopes, the tabular data and charts giving average figures for the five areas observed. The last three sections report the measurements on gullies and deposition in the Las Posas project area and observations of landships, particularly in the La Habra area.

A pictorial section follows the report on pages 16-23. Not all the pictures were taken at the time of the 3-day storm that ended on March 3. Those that were not, however, illustrate practices that are hazardous during such storms or control measures that were tested during that storm.

TYPE OF TREATMENT

The effectiveness of measures of erosion control during abnormally severe storms is indicated by data on soil losses during this storm on both uncontrolled land and land where various types of treatment for the control of erosion are practiced (table 1). The soil losses under particular types of treatment, including both cover and mechanical controls, are recorded in table 2, and in the charts on page 8.

TABLE 1.—Acreage eroded and amount of soil loss on controlled and uncontrolled land on the five areas surveyed, March 1938

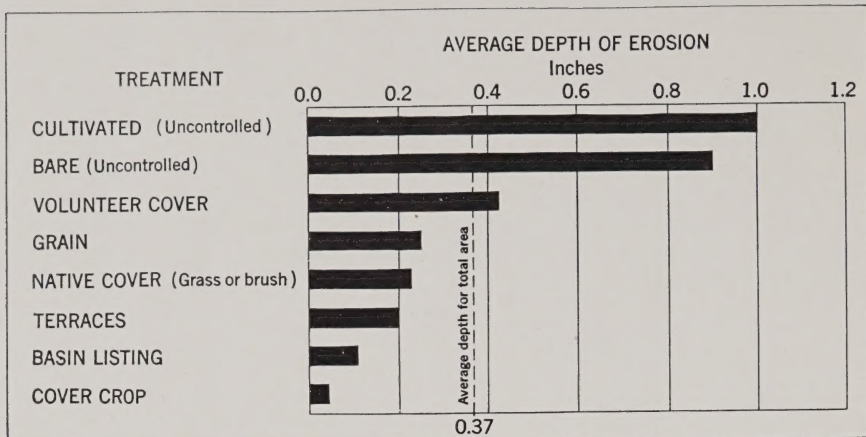
Treatment	Area	Area with no measurable erosion		Area with soil loss of more than 1/8 inch		Average depth of soil loss	Average soil loss per acre
	<i>Acres</i>	<i>Acres</i>	<i>Percent</i>	<i>Acres</i>	<i>Percent</i>	<i>Inches</i>	<i>Cubic yards</i>
Erosion control practiced.....	38,917	29,833	76.7	2,439	6.3	0.05	6.7
Erosion control not practiced.....	102,855	31,879	31.0	46,300	45.0	.49	65.9

The cover crops referred to in table 2 are of the planted types generally used on bench terraces in orchards on moderately or steeply sloping lands. The grainfields were without mechanical controls. The terraced fields had little or no vegetative protection. The average loss on terraced land was materially increased by the extreme

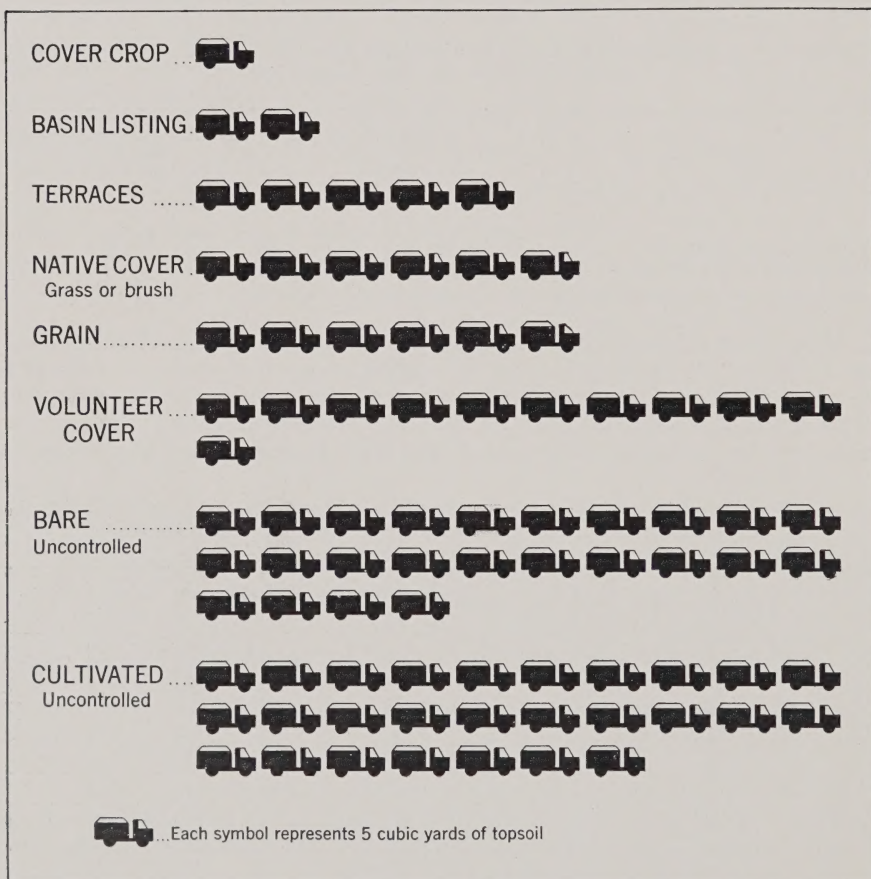
TABLE 2.—Percentage of the area in each type of treatment that was eroded to the depths indicated, from the survey of the five areas, March 1938

Average depth of erosion (inches)	Cover crop	Basin listing	Terraces	Native cover ¹	Grain	Volunteer cover	Bare ²	Culti-vated ³
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
0.....	88	69	12	53	30	37	4	0
1/8.....	9	9	65	24	49	29	17	8
3/8.....	2	22	19	13	9	8	45	37
3/4.....	1	0	2	7	5	17	10	23
1 1/2.....	0	0	2	1	7	4	5	19
3.....	0	0	0	2	0	5	19	13
Total.....	100	100	100	100	100	100	100	100
Area.....acres	32,515	788	5,614	41,160	12,119	15,376	18,495	15,705

¹ Grass or brush.
² Uncontrolled.
³ Uncontrolled; includes fallow-cropped, orchard, and vineyard land.



Average depth of erosion under different types of treatment on the five areas surveyed, March 1938. (See footnote 3, table 2.)



Soil loss in cubic yards per acre for land under various types of treatment on the five areas surveyed, March 1938.

loss from one tract of land whose owner had, contrary to his agreement, failed to subsoil his terraced fields. Native cover included both brush and native grassland. Here again the average loss was raised because on the Las Posas project most of the native cover had been destroyed by fire the previous fall. Volunteer cover refers to land that had been cultivated during the previous season but on which all volunteer growth of the winter had remained. Bare land indicates land on which vegetation had previously been destroyed by cultivation and on which former rains had packed down the soils. Cultivated land is land that had just been cultivated but not packed down.

One outstanding fact made evident by the data on this storm is the necessity for good cover in controlling erosion on both gentle and steep slopes. That it was effective in preventing soil movement even on steep slopes was strikingly demonstrated. Of the area protected by cover crops, 88 percent showed no measurable soil loss, and only one-fourth of the damaged area lost as much as one-fourth inch or more of soil. Although cover crops successfully held the soil, a cover of grain permitted considerable soil loss. This fact indicates that a dense cover is necessary to effect complete erosion control by means of vegetation alone.

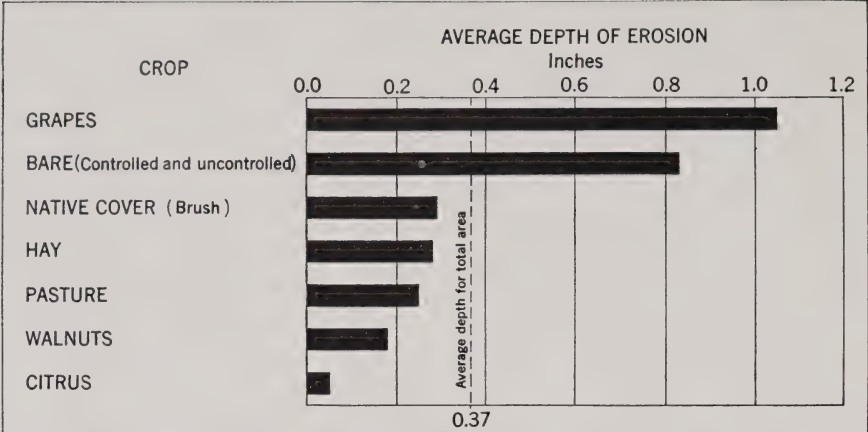
On all project and camp areas, cover crops in conjunction with terracing, basin listing, or annual ditches proved to be particularly effective. Measurements indicate that basin listing and terracing without auxiliary vegetative controls were not so effective as cover crops alone.

At Aliso Creek project, terraces without contour subsoiling or cover cropping were not sufficient to provide adequate protection, whereas basin listing and block furrowing were unquestionably effective. At the La Habra project, terraced grainfields had no measurable erosion, whereas unterraced grainfields lost up to one-eighth inch of soil. On the Palos Verdes C. C. C. area, in Los Angeles County, there was no soil loss on terraced lands lying on slopes less than 15 percent, and it was found that terraces were not needed on land retired from cultivation and sown to native grasses. On the Cucamonga C. C. C. area, in San Bernardino County, annual ditches and terraces functioned effectively.

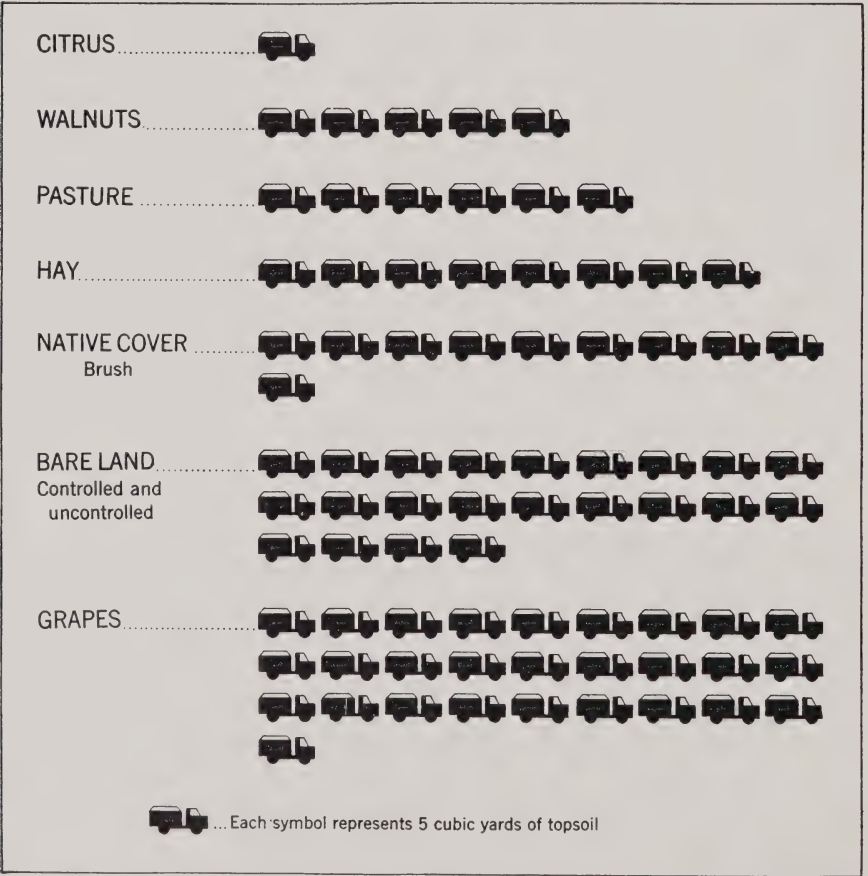
TYPE OF CROP

The effectiveness of a well-rounded program of erosion control was remarkably demonstrated by the small erosional losses in citrus orchards. Avocado groves are classified as citrus in this report, since the treatment is the same as in the citrus orchards. These are the only areas on which a complete control program is generally maintained. Fertilization and irrigation of cover crops is practiced, and the sloping lands are bench-terraced. Table 3 indicates the relation between type of crop and depth of erosion.

Walnut orchards had five times as much soil loss as citrus orchards, but not all of them were protected by cover crops. The average soil loss for land in grapes was particularly heavy because a 3,200-acre vineyard was severely eroded by the concentrated run-off from adjacent hills. Pastures were more resistant to erosion than hay lands. Soil losses under all crops are shown graphically on the following page.



Average depth of erosion under different crops on the five areas surveyed, March 1938.



Soil loss in cubic yards per acre from land in various crops on the five areas surveyed, March 1938.

TABLE 3.—*Percentage of the area in each type of crop that was eroded to the depths indicated, from the survey of the five areas, March 1938*

Average depth of erosion (inches)	Citrus	Walnuts	Pasture	Hay	Native cover ¹	No cover ²	Grapes
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
0.....	76	47	43	15	55	2	46
1/4.....	21	15	26	34	20	15	6
3/4.....	3	13	21	30	12	38	1
3/4.....	0	3	7	6	7	10	18
1 1/2.....	0	2	2	5	2	15	0
3.....	0	0	1	0	4	10	29
Total.....	100	100	100	100	100	100	100
Area.....acres..	30, 741	6, 134	15, 437	18, 746	35, 134	24, 801	10, 779

¹ Brush. ² Controlled and uncontrolled.

CONDITION OF COVER

Table 4 and the chart showing the average depth of erosion under different conditions of cover (p. 12) indicate that the density of the cover makes a striking difference in its effectiveness in resisting erosion. Of 57,090 acres of land with dense cover, on various slopes, 91 percent had no erosion and only 3 percent had a soil loss of more than one-fourth inch. Land with dense cover lost only 2.7 cubic yards per acre; and land with moderate cover lost more than 13 times as much—36.3 cubic yards per acre.

TABLE 4.—*Percentage of the area in each condition of cover that was eroded to the depths indicated, from the survey of the five areas, March 1938*

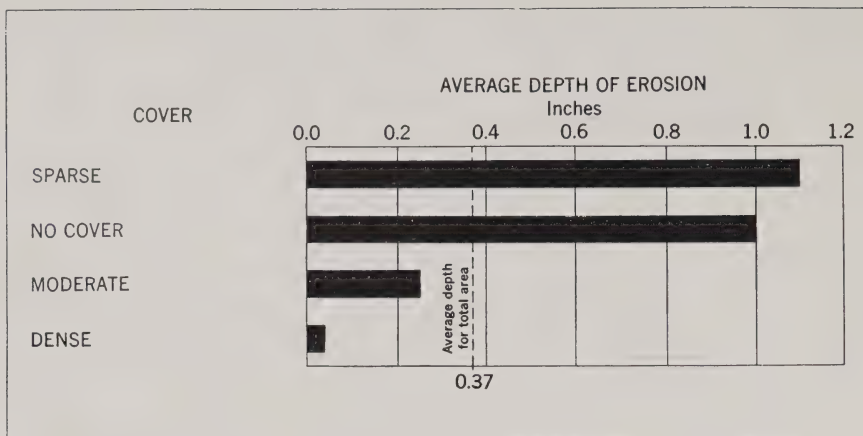
Average depth of erosion (inches)	Dense cover	Mod- erate cover	No cover ¹	Sparse cover	Average depth of erosion (inches)	Dense cover	Mod- erate cover	No cover ¹	Sparse cover
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>		<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
0.....	91	21	1	1	3.....	0	1	18	18
1/4.....	6	43	16	8	Total.....	100	100	100	100
3/4.....	2	26	34	3	Area.....acres..	57, 090	46, 808	30, 940	6, 934
3/4.....	1	7	18	36					
1 1/2.....	0	2	13	14					

¹ Includes some orchard and grape lands and both controlled and uncontrolled bare land.

Sparse cover, however, offered less resistance to erosion than bare land. Land with no cover lost 135.7 cubic yards per acre and land with sparse cover lost 149.2. Sparsely covered land lost more than 55 times as much soil as densely covered land. The high average loss on sparsely covered land was probably influenced by slope, however, since the sparse cover was usually on the steeper slopes. Also, probably the average loss on land without cover was held down because erosion was retarded on a small area of this land protected by mechanical control measures.

SLOPES

Since most of the slopes in the five areas were protected to some degree by vegetation, no direct comparison can be made of the effects of different slopes on erosion throughout the entire 140,000 acres. The La Habra project, which contains the steepest slopes, had a cover



Average depth of erosion under different conditions of cover on the five areas surveyed, March 1938. (See footnote 1, table 4.)

crop on virtually its entire area. The Las Posas was the only project with sufficient bare land to indicate the effect of slope alone. A comparison of the average peak run-off per acre in parts of these two projects indicates the effect of cover in modifying erosional losses.

In this storm, eight Los Posas drainage basins, comprising an area of 17,500 acres, had an average peak run-off per acre of 0.29 cubic feet per second, whereas on nine drainage basins, comprising 6,105 acres of the La Habra demonstration area, where the slopes are steeper and the drainage basins very much smaller, the average peak flow was approximately 25 percent less. The lesser flow from these steeper slopes can be attributed to the protection afforded by the plant cover.

Table 5 shows the average slopes for each erosion group on the three project areas.

TABLE 5.—Average slope of land in the erosion groups in each of the projects in the storm area, March 1938

Erosion group	Average slope in—			Erosion group	Average slope in—		
	Las Posas project	La Habra project	Aliso Creek project		Las Posas project	La Habra project	Aliso Creek project
	Percent	Percent	Percent		Percent	Percent	Percent
1.....	3	15	15	4.....	22		14
2.....	14	31		5.....	24		15
3.....	15	5	7	6.....	37		15

In the La Habra project more soil was lost from the least sloping land, though the average loss here was not greater than one-half inch. However, most of the cover crops on steep slopes are in bench-terraced orchards, and the effectiveness of erosion control on these slopes should be credited to both vegetation and mechanical measures.

To lessen the influence of treatment and cover in determining erosional losses on various slopes each type of treatment was broken

down according to slope (table 6). Steep slopes protected by cover crops or mechanical controls lost less soil than gentle slopes without protection. The steeper slopes that had no protection or were inadequately covered lost more than the gentler slopes similarly protected, as indicated by the losses recorded for grain, bare land, and cultivated land.

TABLE 6.—Average depth of erosion in relation to slope and treatment on the five areas surveyed, March 1938

Type of treatment	Erosion on slopes of —				Type of treatment	Erosion on slopes of —			
	Less than 4 per-cent	4-15 per-cent	15-23 per-cent	23 per-cent and over		Less than 4 per-cent	4-15 per-cent	15-23 per-cent	23 per-cent and over
Cover crop	<i>Inch</i> 0.04	<i>Inch</i> 0.02	<i>Inch</i> 0.08	<i>Inch</i> 0.06	Volunteer cover	<i>Inch</i> 0.35	<i>Inch</i> 0.15	<i>Inches</i> 0.32	<i>Inches</i> 1.24
Grain .....	.02	.18	.30	.56	Bare (uncontrolled) .....	.31	.56	1.65	1.70
Terraces and ditches .....		.24	.14	.13	Cultivated (uncontrolled) .....	.42	.63	1.30	1.87
Basin listing .....	.16	.01	.13						
Native cover .....	.06	.22	.03	.26					

SOILS

Because of the influence of cover, no direct relationship between various types of soil and depth of erosion could be established. A comparison can be made, however, of erosion on various soils under the same type of treatment. Because there were so many soil types, soils were grouped to facilitate comparison. They were divided according to their origin as follows: (1) Recently transported soils, which have deep, loose subsoils; (2) old transported soils, which have shallow, tight subsoils; and (3) primary or residual soils, which are underlain by shallow bedrock. Table 7 shows that in this storm deep soils were much less erodible than shallow soils. Such soils are capable of absorbing rainfall in large amounts. Perhaps in a storm of higher intensity deep soils would not show such a marked superiority. These divisions according to origin were further divided as to texture, into light, medium, and heavy soils. Light means sandy, and heavy means clayey. Heavy soils were more resistant to erosion than medium- or light-textured soils where erosion-control practices were not in effect.

TABLE 7.—Average depth of soil loss in relation to soil and treatment on the five areas surveyed, March 1938

Type of treatment	Recently transported soils (deep, loose)			Old transported soils (shallow, tight)			Primary soils (shallow bedrock)		
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy
Cover crop	<i>Inch</i> 0.03	<i>Inch</i> 0.02	<i>Inch</i> 0.06	<i>Inch</i> 0.21	<i>Inches</i> 0.08	<i>Inch</i> 0.37	<i>Inches</i> 0.13	<i>Inches</i> 0.38	
Grain .....	.03	.28	.11	.48	.25	.43	.22	.29	0.15
Terraces .....	.00	.24		.24	.39			.11	.00
Basin listing .....	.01	.12	.38		.09				
Native cover .....	.11	.34	.06	.48	.49	.15	.22	.24	.14
Volunteer cover .....	.20	.14	.09	.26	.55	.53	1.38	.96	1.22
Bare and uncultivated .....	.31	.36	.26	1.59	.80	.75		1.93	
Bare and cultivated .....	.56	.49	.37	2.00	1.10	1.00	.65	2.28	.29

GULLIES

In this storm much less soil was lost by gully erosion than by sheet erosion. In the survey, any water channel with an average cross-sectional area of 1 or more square feet was classed as a gully. Table 8 shows the number and size of new gullies and the amount of soil lost from them on land under the different types of treatment on the 40,000-acre Las Posas demonstration area in Ventura County.

TABLE 8.—*New gullies in relation to type of treatment, in the Las Posas demonstration area, March 1938*

Type of treatment	Area	New gullies	Average length of gully	Total length	Soil loss
	<i>Acres</i>	<i>Number</i>	<i>Feet</i>	<i>Feet</i>	<i>Cubic yards</i>
Cover crops.....	3,900	20	155	3,100	5,480
Grain.....	4,500	44	220	9,655	20,900
Terraces.....	660	12	171	2,045	13,990
Basin listing.....	370	4	373	1,490	2,320
Native cover.....	7,000	31	92	2,850	26,750
Volunteer cover.....	5,050	60	161	9,935	43,890
Bare and uncultivated.....	2,000	13	510	6,625	15,710
Cultivated recently.....	15,400	510	195	99,225	380,940
Miscellaneous.....	600	24	17	400	300
Total.....	39,480	718	189	135,325	510,280

Probably the most important factor governing the formation of gullies during a storm is the condition of the land at the time of the storm. While only 39 percent of the Las Posas area had been recently cultivated, 71 percent of the new gullies occurred in these bare, cultivated fields, and 75 percent of the soil lost was from gullies eroded in this land. It is significant that the same measures that prevent sheet erosion also prevent gullies. The effectiveness of plant cover is shown by the relatively small number of gullies that were gouged out in land under cover.

With a few exceptions, dams, drops, and revetments that had been installed in old gullies successfully withstood the impact of run-off water. No general measurement of their relative value could be made. At the Aliso Creek project, a 1,000-foot gully channel that was protected by revetments and drops carried the peak flow of the flood without damage, whereas an adjoining unprotected section of the same channel lost 2 cubic yards of soil per linear foot of bank.

Seventy-two gully-control dams in the Las Posas area impounded 27,570 cubic yards of silt and sand, and 12 silt-impounding structures retained 187,600 cubic yards of material. The 215,170 cubic yards was, however, only a small portion of the 4,287,000 cubic yards of soil that were washed away. Most of these millions of cubic yards of rich topsoil were washed onto productive land or into the streams and the ocean.

Accuracy of estimated capacities of control works was demonstrated in eight large barrancas in the Las Posas project, where the actual flow was 91 percent of the estimated high flow. Failure of gully-control structures throughout the five areas was less than 1 percent.

DEPOSITION

Data on lands damaged by deposition in the Las Posas project area are given in table 9. The table reveals that the total amount of deposit was equal to more than 31 cubic yards of soil per acre for every acre in this project area. For every 100 acres of watershed there were approximately 2.8 acres of agricultural land damaged by deposition.

It seems possible that further observations regarding watershed run-off as related to off-watershed damage might lead to a new and useful yardstick for evaluating watersheds in their relation to adjacent agricultural and urban areas.

TABLE 9.—*Deposition in relation to crops in the Las Posas demonstration area, March 1938*

Crop	Area covered by—		Deposition		Area of contributing drainage basin	Average area over-washed per 100 acres of contributing drainage basin
	Silt	Sand	Depth	Amount		
	<i>Acres</i>	<i>Acres</i>	<i>Feet</i>	<i>Cubic yards</i>	<i>Acres</i>	<i>Acres</i>
Pasture.....	.....	3	1.0	4,840	150	2.0
Brush.....	.....	22	1.5	52,240	1,400	1.6
Walnuts.....	10	.....	.3	4,840	285	3.5
Do.....	.....	45	.7	50,820	1,005	4.5
Citrus.....	.....	71	.9	103,090	3,625	2.0
Other.....	.....	3	.4	1,940	170	1.8
Hay.....	.....	87	.3	42,110	3,920	2.2
Do.....	3	.....	.2	970	10	30.0
Bare.....	37	.....	.3	17,910	994	3.7
Do.....	.....	123	.6	119,060	2,832	4.4
Total or average silt.....	50	.....	.....	23,720	1,289	3.9
Total or average sand.....	.....	354	.....	374,100	13,102	2.7
Total or average silt and sand.....	.....	404	.....	397,820	14,391	2.8

LANDSLIPS

Storms of low intensities and long duration, such as this one, produce maximum saturation of the soil and therefore present favorable conditions for soil slippage. As water-conservation practices also provide for maximum saturation of soils, it might be reasoned that areas where conservation treatments are employed offer more favorable conditions for slippage than untreated soils. In some instances the records of this storm bear this out. No slips, however, occurred on slopes of less than 40 percent, and slides were just as frequent on steep pastures as on bench-terraced orchards protected by cover crops.

Primary soils were found to be most susceptible to slips. The shallow depth and underlying impervious strata were largely responsible for the 100 landslips in the 25,000 acres in the La Habra project, which includes the steepest agricultural land in the areas surveyed. The numerous slips that occurred on its slopes emphasize the importance of a careful study of conditions, particularly of the soils, before soil and water conservation methods are applied to such steep land.

COVER



A dense early cover of *Melilotus indica* protects this 2-percent slope in Ventura County. Such areas as this were classed in this report as having no apparent erosion.



At the left is an untterraced orchard, without a cover crop. Most of the topsoil was washed from this orchard during the storm of March 2 (February 28 to March 3). Part of this heavy soil loss was caused by run-off from adjacent land.



On steep slopes planted to citrus fruits, bench terraces and thick growing winter cover crops afford protection for the soil. Contour planting and other erosion-control practices have held the soil in the orchard in Ventura County that is shown below.

That orchards without a protective cover are subject to heavy losses of soil is shown in this picture of an apricot orchard in Ventura County (right). An average depth of $1\frac{1}{2}$ inches of soil was washed from the clean-cultivated orchard in a storm in 1934. The pasture across the fence lost no soil.



The picture below, taken about a week before the storm of March 2, shows the cover crop in an apricot grove in Ventura County. During that storm this cover held the soil.





MECHANICAL CONTROLS

During the storm of March 2, 3 inches of soil was washed from this field (left) to pile up among the trees on a valuable orange orchard. On a slightly steeper slope of similar soil in a neighboring county (opposite page, top), basin listing and a cover crop hold the soil and water. This basin-listed field was photographed after a 4-inch rain in 2 days. During the storm of March 2 also it held the water and therefore lost no soil.

Below is shown a comparatively level, clean-cultivated beanfield that was severely eroded in this storm. Basin listing, broad-base terracing, and contour subsoiling have proved successful in controlling erosion and conserving water on similar slopes. Successfully operating terraces in Los Angeles County (center) and contour subsoiling in Orange County (bottom) are pictured on the opposite page. In the field in Orange County, hillside ditches were installed and the land was contour-subsoiled before the storm. During this storm the contour subsoiling alone retained practically all the water on the field. The ditches served to intercept what little water ran off and to prevent dangerous concentrations. Similar fields had been ditched but not subsoiled. Most of them were severely washed, and many breaks occurred in the ditches.





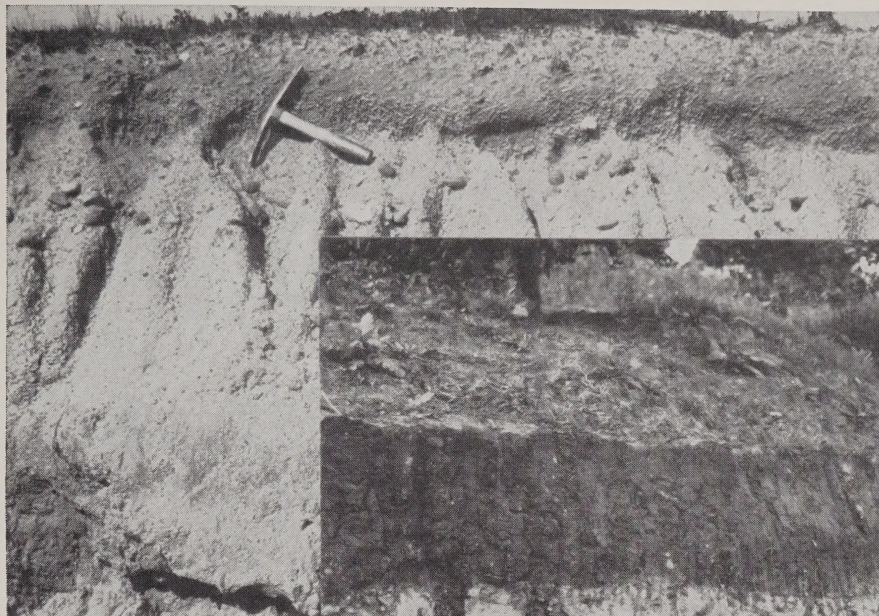
SLOPES

It is treatment of a slope rather than the steepness of slope that largely determines the severity of erosion. In the field to the left, rills have cut the untraced slope to the point where the natural cover begins.



In the beanfield shown below, severe erosion begins at the foot of the steep hill, on land planted exclusively to beans year after year. During 1935 and 1936 the hill in the background was retired to a cover crop, which was plowed under in the spring of 1937. The entire field was planted to beans in 1937 and was clean-cultivated during the winter of 1937-38. The upper part of the field was cultivated once; the middle part, twice; and the lowest part, four times. The effect of the organic matter left in the soil by turning under the cover crop on the hillside is clearly shown in the greater number and size of the rills on that part of the field kept continuously in beans.





SOILS

Old transported soil (left)—fine clayey particles have had time to collect at shallow depths to form a dense and relatively impervious subsoil. Primary soils (right) overlie the parent rock from which they originate. Usually these soils are very shallow, and they generally lie on steep slopes. Recently transported soils (below) show the same characteristics throughout their entire profile, often to a great depth.



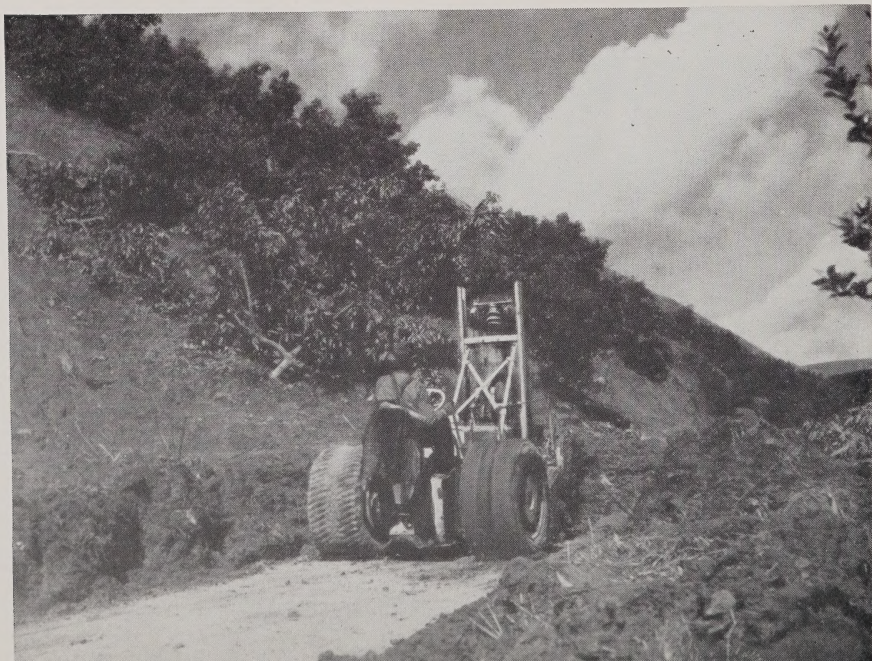


Deposition from clean-cultivated bean land 2 miles away covered this Persian (English) walnut orchard to an average depth of 3 feet during the storm of March 2.

DEPOSITION

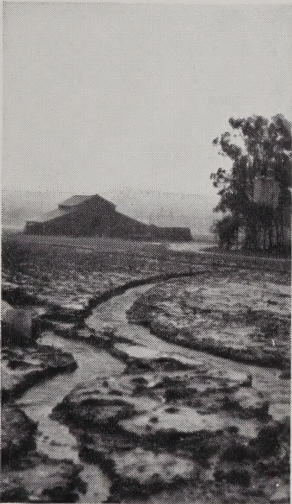
LANDSLIPS

During this same storm, these bench terraces became saturated and slipped. On less than 10 acres of hillside land, 70 full-grown avocado trees were destroyed by landslips. County road-maintenance crews had to clear the roads.



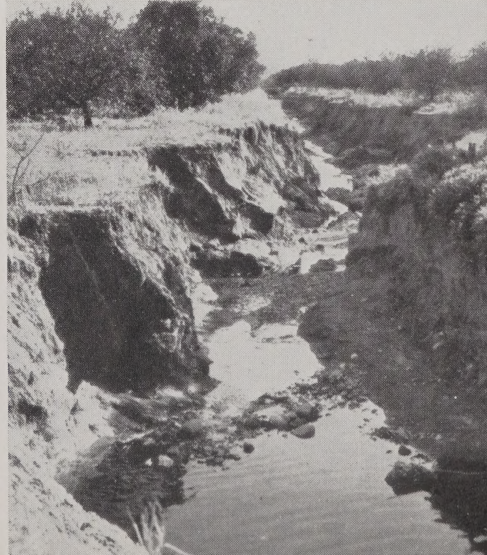
GULLIES

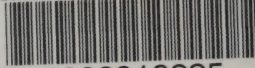
In this orchard a gully has begun to work its way up the slope in the furrow made by a root-cutting machine that was operated up and down the slope to cut off long roots extending into the grove from the windbreak on the left.



During a heavy rain, run-off from relatively flat fields (left) is enough to start erosion that may develop into gullies if it is left unchecked.

Below: Neglect of drainageways is one means of giving gullies a start. By building a few inexpensive dams and using grass to supplement this control, one farmer made a drainageway that carried run-off without gullyng (left). Another, who neglected to provide a controlled drainageway (right), saw the run-off from 10 inches of rain in 2 weeks deepen this gully as much as 10 feet in some places. Each year it will continue to increase in depth and width unless expensive control measures are installed.





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